

II. Account of Levellings carried across the Isthmus of Panamá, to ascertain the relative height of the Pacific Ocean at Panamá and of the Atlantic at the mouth of the river Chagres ; accompanied by Geographical and Topographical Notices of the Isthmus. By JOHN AUGUSTUS LLOYD, Esq. Communicated by CAPTAIN SABINE, Secretary of the Royal Society.

Read November 26, 1829.

IN November 1827 I received a special commission from General BOLIVAR to make a survey of the Isthmus of Panamá and Darien, in order to ascertain the best and most eligible line for a communication (whether by road or canal) between the two seas. On my arrival in Panamá in March 1828 I was joined by a brother officer of Engineers, a Swede in the Colombian service, a good mathematician and of habits of great correctness in observation.

Upon consulting together, we found that we could combine the particular object of the commission with a second object in which we both felt a deep interest, namely, the determination of the relative height of the ocean on either side of the Isthmus ; and that we could best accomplish both, by taking a part of the present line of road between Porto Velo and Panamá, until we should fall in with the river Chagres about twenty miles above Cruces, which village is the usual landing-place for all articles of commerce in their transit from the North Sea to Panamá.

To avoid delay, we commenced our operations on the 5th of May, although the rainy season had for some days set in ; being resolved to overlook the absence of personal comfort, the unhealthiness of the season to a European constitution, the inadequacy of our means, and various other difficulties unnecessary to enumerate, as we finally succeeded in surmounting them.

The instruments used for the levelling were,—A 20-inch spirit level of CAREY's best construction, with extra telescopes, levels, shade tubes, &c., which I received from the museum at Bogota ; a pair of excellent station staves made by HARRIS and graduated as usual, with vernier scales added by myself to read off to thousandths of a foot when required ; GUNTER's chains ; an

excellent 10-inch theodolite by CAREY; and a very fine altitude and azimuth circle for the survey.

Our first level commenced at the end of the street called Callé Sal si Puede in the suburbs of Panamá and at the point of a bay called Playa Prieta, at spring tide high-water mark, observed two days after full and change, which I had subsequently the opportunity of verifying on my return to Panamá, and of ascertaining that it was 3.03 feet lower than the extreme rise of occasional tides under the influence of particular winds. From this point we followed the old road to Porto Velo, and after 732 pairs of levellings in a distance from Panamá of 1828 chains ($22\frac{3}{4}$ miles), we arrived at the banks of the Chagres on the 30th of June, 633.32 feet being the greatest height we had passed over; and after building a secure station on the bank 169.84 above the level of high water mark in the Pacific, we finished our operations for that year, on account of the great inclemency of the season, the sickness and debility of the people employed, and from our own constitutions beginning to suffer by continued exposure to incessant rains, with generally no other covering than tents and ranchos or small huts built by ourselves.

On the 7th of February 1829, the dry season having for some time set in, we resumed our levelling at the station at which we had desisted the year before, having the instruments in good repair; and having descended to a station on the river fixed on for the purpose, we found the surface of the water to be 152.55 feet above high-water mark in Panamá.

We now followed the course of the river, and were enabled thereby to take longer levels than before, which were made with the greatest possible care, reducing the observations to the true levels by the most exact tables for the curvature of the earth.

After 68 pairs of levellings we arrived at Cruces in a distance of 1545 chains ($19\frac{1}{4}$ miles), and found a fall in the river of 114.60 feet, leaving only 37.96 feet above the Pacific. Having nearly 50 miles more to descend, and finding so great a fall in 19 miles, we were led to expect a greater fall than 37.96 feet in the remaining distance; and consequently, at this stage of our operations, to apprehend that we should find the level of the sea at Panamá to be higher than at the mouth of the Chagres.

From Cruces to a town called Gorgona, distant 419 chains ($5\frac{1}{4}$ miles), there is

a fall of only 16.13 feet, and thence to a small gravel bank named by us "Playa de los Injenieros," distant altogether 1302 chains ($16\frac{3}{4}$ miles) from Cruces, we found a fall from Gorgona of 21.82 feet, to a station precisely level with the high-water mark of spring tides in the Pacific, still being 34 miles from the mouth of the river. From this point we descended below the level of high-water-mark of the Pacific, until we arrived at a place called Palo Matias, distant from Cruces 2682 chains ($33\frac{1}{2}$ miles), and from the commencement of the levels in the river 4227 chains ($52\frac{1}{2}$ miles) : at this point we first observed the effects (slight as they were) of the tides of the North Sea, and the height of the water was 13.65 feet below the high-water mark at the Pacific ; this we therefore concluded to be the level of high-water mark in the Atlantic. We however continued our levellings 507 chains further, to a place called La Bruja, nearly 12 miles distant from the mouth of the Chagres, where the water in the dry season is very brackish, and from whence there is no perceptible current to the sea: here we found the level of the surface of the water, by several observations at the time of high water in Chagres, to be 13.55 feet below the high-water mark in the Pacific, being 0.1 of a foot less than at Palo Matias, the difference being occasioned by our not having observed the tides at the former place so correctly as at the latter, as we determined to finish the observations at La Bruja. After 935 pairs of levellings, therefore, in a distance of nearly 82 miles, we found high-water mark in the Pacific to be 13.55 feet higher than high-water mark at La Bruja, which, from the circumstances above mentioned, is considered to be the high-water level of the Atlantic at Chagres.

The details of all the operations connected with the levellings are contained in a manuscript deposited in the library of the Royal Society; they are further illustrated by a section of the whole on the scale of four inches to a mile.

No proof levels were taken. I was aware, from the commencement, of the nature of the task I had entered upon, and knew too well that if I had the good fortune to be able to persevere a sufficient time to carry the levelling across the Isthmus, I should be but little capable of remaining during a third year, which such verification would have required. I therefore adopted such a scrupulous and rigid mode of proceeding as would render a verification unnecessary, and prevent the intrusion of even a trifling error ; an important one I am bold to say was nearly impossible. In the whole distance overland to the river Chagres, my companion being employed with the chain, I was

assisted by a Spaniard whom I had previously instructed in the management of the station staff. By means of signals I made him adjust the cross-piece correctly to the horizontal wire of the telescope; he then brought me the staff, which I read off and noted down the reading; he resumed his station, I examined the level again, adjusted the staff, recalled the Spaniard, and read off a second time.

From the Chagres to the last level my companion had the station staff himself, which when adjusted to the cross-wires was read off by him. I then re-examined the level, adjusted the staff a second time, and he again read off, writing down the two observations in distinct books, which were compared in the evening. The instrument itself I proved on most days after work, by making a set of 8 or 10 levellings in a circle; returning in the last station to the point from which I first started, and finding the sum of the differences of the levellings amount to zero.

The point from which the levellings commenced at Panamá is marked by a large stone cut for that purpose in the wall at the edge of the sea in Playa Prieta; and the concluding point at La Bruja, by a tree cut down to the exact height marked in the Observation Book above the surface of the water: the height of the section of the tree is 6.848 feet below the level of high-water spring tide at Panamá. No better means of marking this level presented itself at La Bruja; but by a reference to the manuscript detail of the observations preserved in the library, several stations are to be found in the vicinity which are not liable to decay.

By careful and continued observations, I found the rise and fall of the tide in the Pacific at Panamá as follows: between the extreme elevation and depression of the waters by occasional tides there is a difference of 27.44 feet, and the mean actual rise and fall two days after full moon is 21.22 feet.

At Chagres I observed the rise and fall of the tide at the close of the dry season in April 1829 to be 1.16 foot, and being there subsequently during the rainy season, I had an opportunity of observing that the high-water mark was the same in both seasons.

The time of high water is nearly the same at Chagres and at Panamá, namely at 3^h 20^m at full and change: hence the following interesting and curious phenomena are deducible in respect to the difference of level of the two seas.

First.—High-water mark at Panamá is 13.55 feet above the high-water mark

of the Atlantic at Chagres ; half the rise and fall of spring tides is at Panamá 10.61 feet, and at Chagres 0.58 of a foot ; and assuming half the rise and fall above the low water of spring tides to be the respective mean levels, the mean height of the Pacific at Panamá is 3.52 feet higher than that of the Atlantic at Chagres*.

Second.—At high water, the time of which is nearly the same on both sides the Isthmus, the Pacific is raised at mean tides 10.61 feet, and the Atlantic 0.58 of a foot, above their respective mean levels ; the Pacific is therefore the highest at such times by $(10.61 - 0.58 + 3.52 =) 13.55$ feet.

Third.—At low water, both seas are the same quantities below their respective mean levels ; therefore at such times the Pacific is lower than the Atlantic by $(10.61 - 0.58 - 3.52 =) 6.51$ feet.

In every twelve hours therefore, and commencing with high tides, the level of the Pacific is first several feet higher than that of the Atlantic ; it becomes then of the same height, and at low tide is several feet lower : again, as the tide rises the two seas are of one height, and finally at high tide the Pacific is again the same number of feet above the Atlantic as at first.

Almost every person who visits Panamá from the Atlantic side is disposed to think that the country rises from the Atlantic to the Pacific. The ascent of the river Chagres, particularly when swollen by rains and its current rendered more than usually rapid, is very toilsome ; and on reaching Cruces after a four or five days tedious journey, a traveller is impressed with the persuasion that he has gained a considerable elevation above the sea that he has quitted : this impression is not diminished by the journey to Panamá, which is mostly through rough and rugged passes, continually ascending and descending ; and when, on arriving in the savannahs, a few miles from Panamá, the city is beheld for the first time with its conspicuous cathedral, the general exclamation is, "I thought Panamá had been near the level of the sea." Such is actually its situation ; but as the valley from which it is first seen is several feet below the level of the sea, the first and strong impression produced, is that the city stands upon an eminence.

* The author is aware that there are different opinions with regard to what is the mean level of the ocean ; the assumption in the text is conformable to his own opinion, but as the data are given from which the conclusions are drawn, every person is furnished with the means of making his own deductions.

Topographical and Geographical Notices.

In the map which accompanies this memoir, the coast line on both sides the Isthmus is taken from the best Spanish authorities, including some very recent corrections; the interior is wholly from my own observations.

The district which extends from Panamá along the old road to Porto Velo, as far as its meeting with the river Chagres, and for three to five miles on either side, is from a survey made by my companion Captain FALMARC and myself, whilst levelling through this part of the country, in the operations already described. The angles and bearings were taken with a 10-inch theodolite by CAREY, with a needle as exact as could be provided for an instrument of that size. On a separate plan (in MSS. deposited in the Society's library,) are marked the stations of the survey, and the intersection of the bearings taken from them. The principal stations are as follows:—The Cerros or Mountains of Ancon, Caledonia, Vidrio, Lirio, Algarobo, Pelado, Largo, Gordo, San Sonati, Alto, de Las Lajas, Maria Henrique, Grenadilla, &c.

From these stations, the surrounding country was sketched at once on the rough map: the same mode was continued from the point where the levellings intersected the river Chagres to the mouth of the river, including as much of the surrounding country as could be laid down by intersecting bearings, taken on either side the river.

The country west of the road from Cruces to Panamá, including a few miles of the coast by Arayjan and Chorrera, was traversed in various directions with a compass, every accessible eminence was ascended, and views taken of the country.

The country between the northern banks of the river Chagres and the North Sea was examined and sketched in an excursion in which I ascended the river Gatun, with a boat compass, and crossed from thence on foot by the gold mines of Santa Rita, (where is gained a fine view of the northern coast to La Enseñada de las Minas,) and thence to the sea beach: from this point I pursued the coast line to Porto Velo, and recrossed the Isthmus to Panamá on foot, in the route marked in the map, which is the old and only road from Porto Velo to Panamá, taking careful bearings from eminences over which I passed,

and gaining as many views of the surrounding country as I possibly could, by climbing the highest trees with a small tomahawk, particularly noticing the direction and figure of the Cordillera to the east and west.

The more direct line from Porto Velo to Panamá, passing through the river Chagres at a place called Calle Limon, is laid down from a manuscript furnished by a Spaniard, who with a circumferentor and a cord of 200 varas crossed from Porto Velo to Panamá as nearly north and south as possible.

It is generally supposed in Europe that the great chain of mountains which in South America forms the Andes and in North America the Mexican and Rocky Mountains, continues nearly unbroken through the Isthmus. This however is not the case: the northern Cordillera breaks into detached mountains on the eastern side of the province of Veragua. These are of considerable height, extremely abrupt and rugged, and frequently exhibit an almost perpendicular face of bare rock. To these succeed numerous conical mountains rising out of savannahs and plains, and seldom exceeding from 300 to 500 feet in height. Finally, between Chagres on the Atlantic side, and Chorrera on the Pacific side, the conical mountains are not so numerous, having plains of great extent interspersed, with occasional insulated ranges of hills of inconsiderable height and extent. From this description it will be seen that the spot where the continent of America is reduced to nearly its narrowest limits, is also distinguished by a break for a few miles of the great chain of mountains, which otherwise extends, with but few exceptions, to its extreme northern and southern limits.

This combination of circumstances points out the peculiar fitness of the Isthmus of Panamá for the establishment of a communication across.

On the east of the line from Panamá to the Bay of Limon, the mountains again commence, gradually thicken, and become more elevated until they connect and form Cordilleras extending from Porto Velo to the Bay of Mandinga, from whence there is another break in the province of Darien and Choco, after which the land rises into a Cordillera on a very extended scale and of very great elevation.

Two lines are marked on the map, commencing at a point near the junction of the rivers Chagres and Trinidad, and crossing the plains, the one to Chorrera and the other to Panamá. These lines indicate the directions which I consider

the best for a rail-road communication. The principal difficulty in the establishment of such communication would arise from the number of rivulets to be crossed, which, though dry in summer, become considerable streams in the rainy season.

The line which crosses to Chorrera is much the shortest, but the other line has the advantage of terminating in the city and harbour of Panamá.

The country intersected by these lines is by no means so abundant in woods as in other parts, but has fine savannahs, and throughout the whole distance, as well as on each bank of the river Trinidad or Capira, presents flat and sometimes swampy country, with occasional detached sugar-loaf mountains, interspersed with streams that mostly empty themselves into the Chagres.

Should a time arrive when a project of a water communication across the Isthmus may be entertained, the river Trinidad will probably appear the most favourable route. The river is for some distance both broad and deep. Its banks are also well suited for wharfs, especially in the neighbourhood of the spot from whence the lines marked for rail-road communications commence.

As the river Chagres has been greatly dwelt on in the writings of those who have discussed the probability of communications being established between the two seas, and as considerable expectations have been formed of the facilities it might afford towards a water communication, I have given a separate plan of the river from its mouth to the point at which it was intersected by the levellings. (This plan will not admit of reduction within the compass of the plates in the Philosophical Transactions, but will remain in the Society's library, where it may be consulted. A plan of the river on a less minute scale is contained in the general map.)

The distances along the river were measured by a strong line of 10 chains in length, substituted for the usual measuring chain, properly subdivided, and its length occasionally verified ; the cord was borne usually by five men, but when required in the shallow and rapid water, by as many as ten men ; and when the water became too deep for the men to wade, canoes were employed to stretch the line. The soundings were taken by a man with a sounding line marked to half feet, seated behind me in the canoe ; so that I could observe the line myself at every cast. The casts were generally between 30 and 40 yards

from one another, and the depth of water was inserted in a sketch of the river which I was at the same time engaged in making.

The river, its channel, and the banks, which in the dry season embarrass its navigation, are laid down in the manuscript plan with great care and minuteness. It is subject to one great inconvenience, that vessels drawing more than 12 feet water cannot enter the river, even in perfectly calm weather, on account of a stratum of slaty limestone, which runs, at a depth at high water of 15 feet, from a point on the main land to some rocks in the middle of the entrance of the harbour, and which are just even with the water's edge ; which, together with the lee current that sets on the southern shore, particularly in the rainy season, renders the entrance extremely difficult and dangerous. The accompanying plan of the harbour will sufficiently explain the inconveniences it is liable to.

The value of the Chagres considered as the port of entrance for all communications, whether by the river Chagres, Trinidad, or by rail-roads across the plains, is greatly limited from the above-mentioned cause. It would prove in all cases a serious disqualification, were it not one which admits of a simple and effectual remedy, arising from the proximity of the Bay of Limon, otherwise called Navy Bay, with which the river might easily be connected : the coves of this bay afford excellent and secure anchorage in its present state, and the whole harbour is capable of being rendered, by obvious and not very expensive means, one of the most commodious and safe harbours in the world.

By the good offices of H. M. consul in Panamá, and the kindness of the commander of H.M. ship Victor, I obtained the use of that ship and her boats in making the accompanying plan of this bay. The shores are laid down trigonometrically from a base of 5220 yards, the situation of which is marked ; and the soundings were taken by myself with the assistance of the master. It will be seen from this plan that the distance from one of the best coves (in respect to anchorage) across the separating country from the Chagres, and in the most convenient track, is something less than three miles to a point in the river about three miles from its mouth.

I have traversed the intervening land, which is particularly level, and in all respects suitable for a canal, which, being required for so short a distance, might

68 MR. LLOYD'S LEVELLINGS ACROSS THE Isthmus of PANAMA¹.

well be of sufficient depth to admit vessels of any reasonable draft of water, and would obviate the inconvenience of the shallow water at the entrance of the Chagres.

I have felt that I might be expected to state my own opinion of the mode that offers the greatest facility for communications across the Isthmus, since my examination and surveys were made for that specific purpose, and I have accordingly done so ; but I have endeavoured at the same time to render the topographical representation of the country sufficiently detailed to enable others to draw such conclusions as may perhaps deserve to be preferred to mine, with almost as much advantage as if they had themselves visited the country.

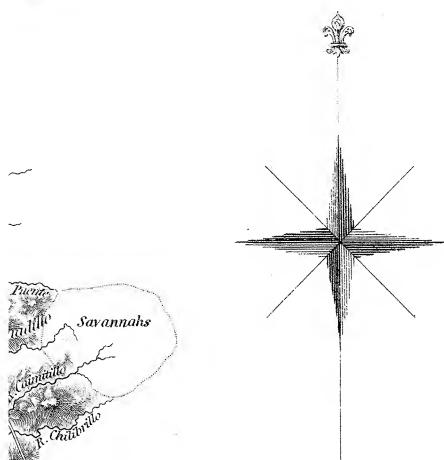
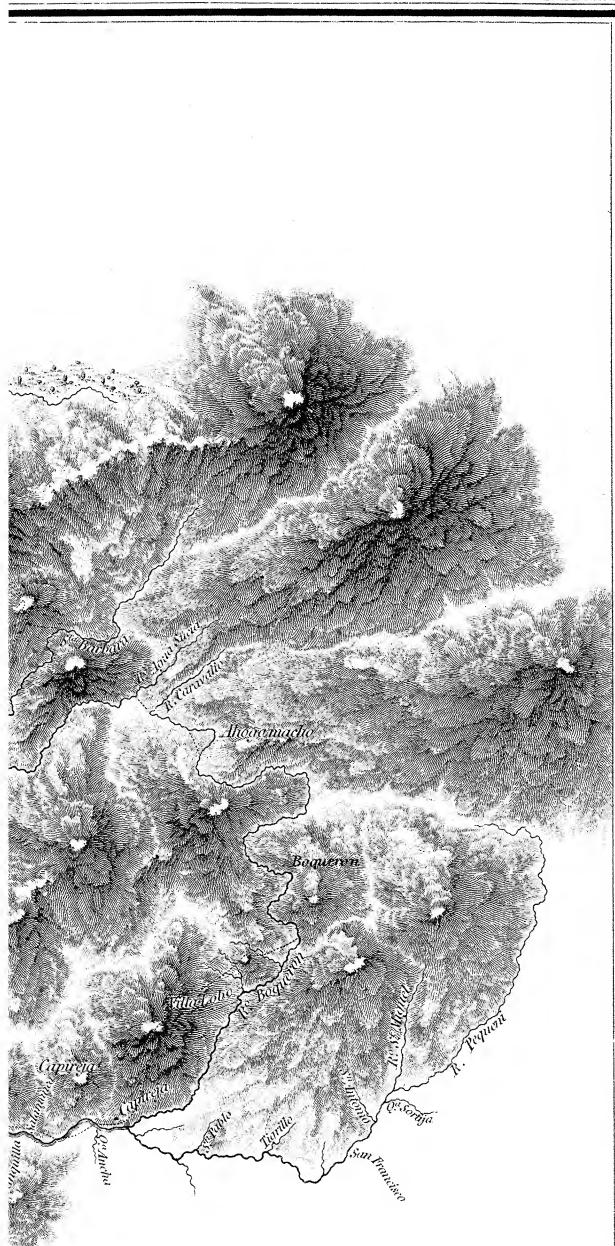
For the opportunities that I have thus enjoyed of contributing correct topographical knowledge of a part of the world, which from its peculiar locality has attracted much philosophical and commercial interest, I am indebted to the authority and support which I received from General BOLIVAR ; I am also indebted to his liberality for permission to make public the information I have acquired.

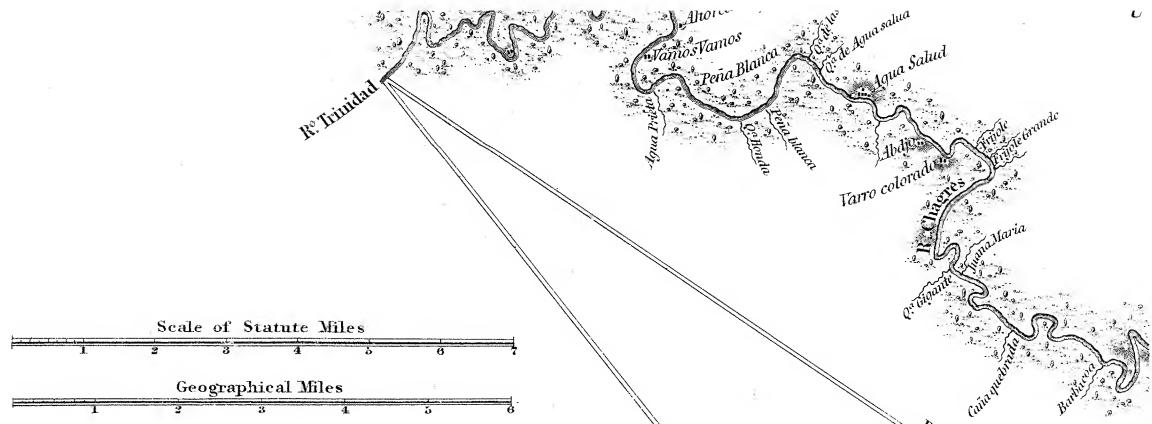
In a country in many respects so unsettled, it will readily be imagined that the authority and countenance, derived from a Government far from the spot, are not alone sufficient to enable a foreigner to carry through operations so extensive and long-continued as mine were. I am sensible that I could not have completed them, had it not been for the frequent assistance and constant support, which I received from the friendship of MALCOLM MACGREGOR, Esq. H. M. consul at Panamá.

PLAN
of that Part of the
ISTHMUS of PANAMA,
Eligible for effecting a Communication
BETWEEN
The Atlantic & Pacific,
from Observations & Surveys performed in the Years 1828. & 1829.
By J. A. LLOYD.



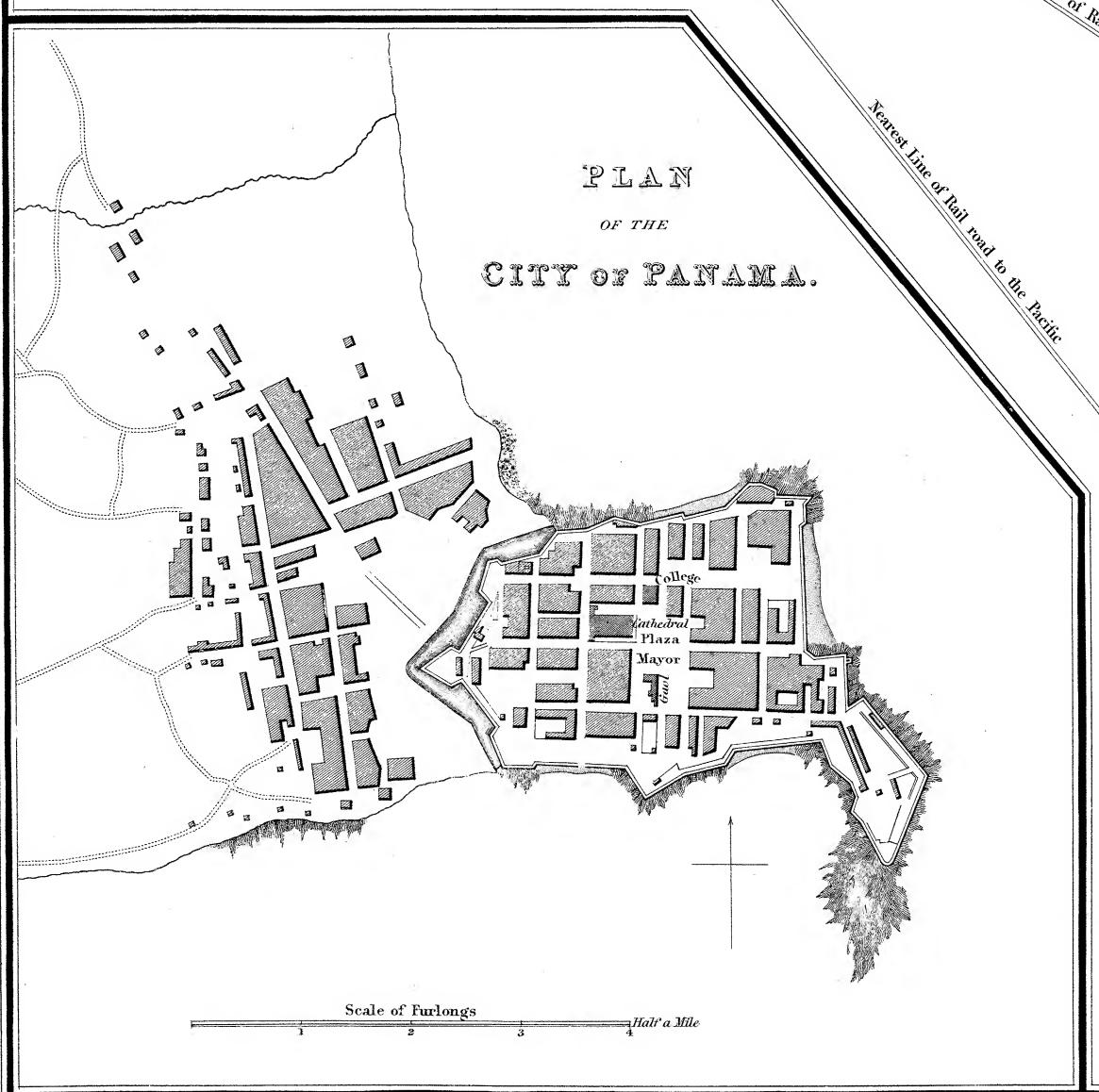






PLAN
OF THE
CITY OF PANAMA.

A map of California showing a rail road line originating from the Pacific Ocean at San Francisco and extending inland through the state.







Engraved by J. Barber

La Bruja, level with High Water Mark at Chagres.

High Water Mark at Panama.

Low Water do. do.

61

Peña blanca

69

63

67

55

51

53

41

40

39

R. Chilibre 53.396 ft.

R. de la Puente 115.992 ft.

R. Pequeni 125.481 ft.

Q^a Sota Caballo
103.873 ft.

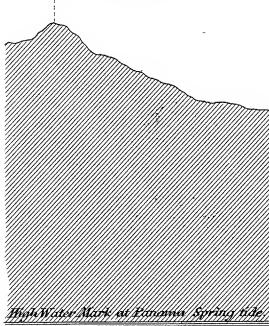
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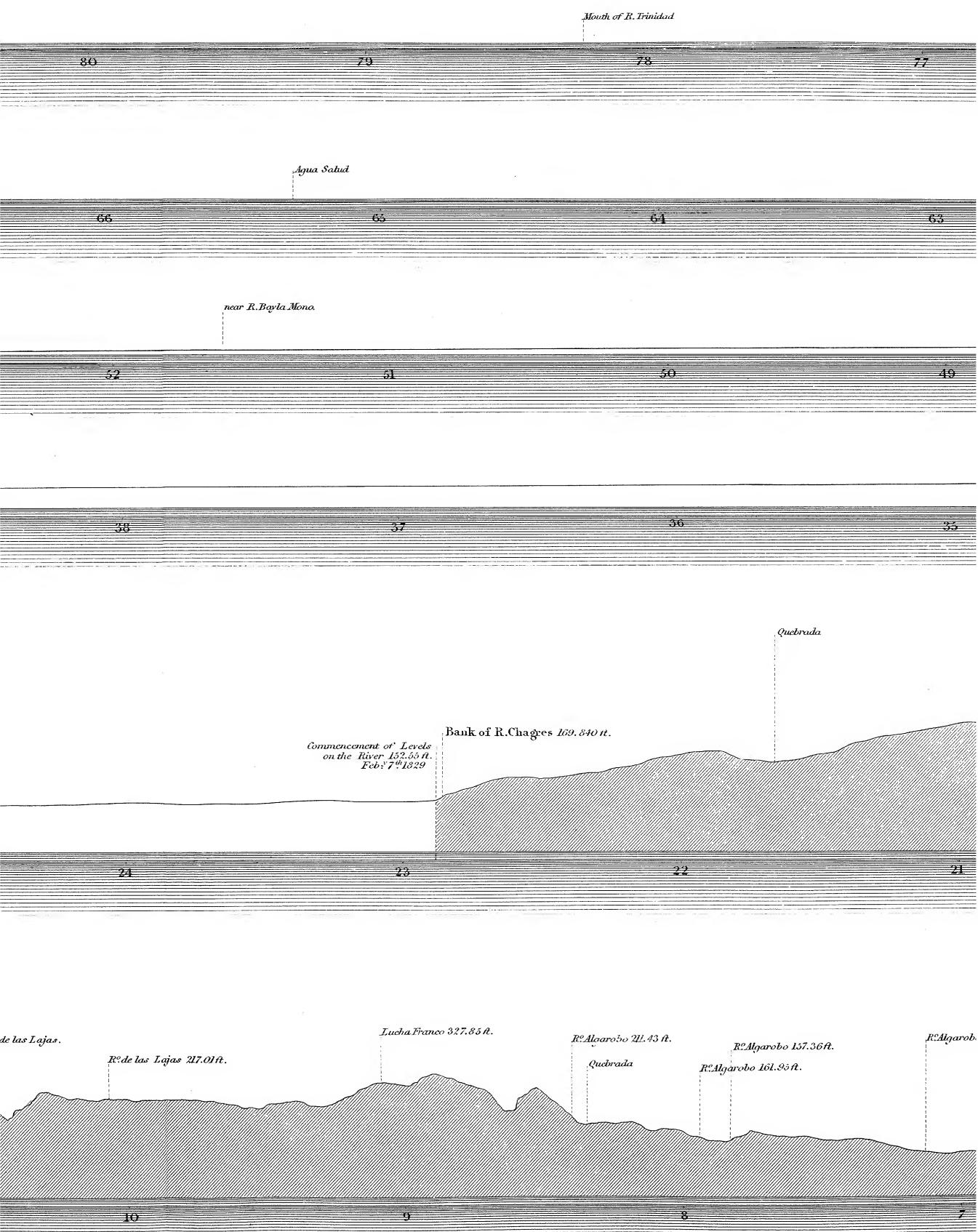
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Maria Henrique.
The Summit Level 633.32 ft.

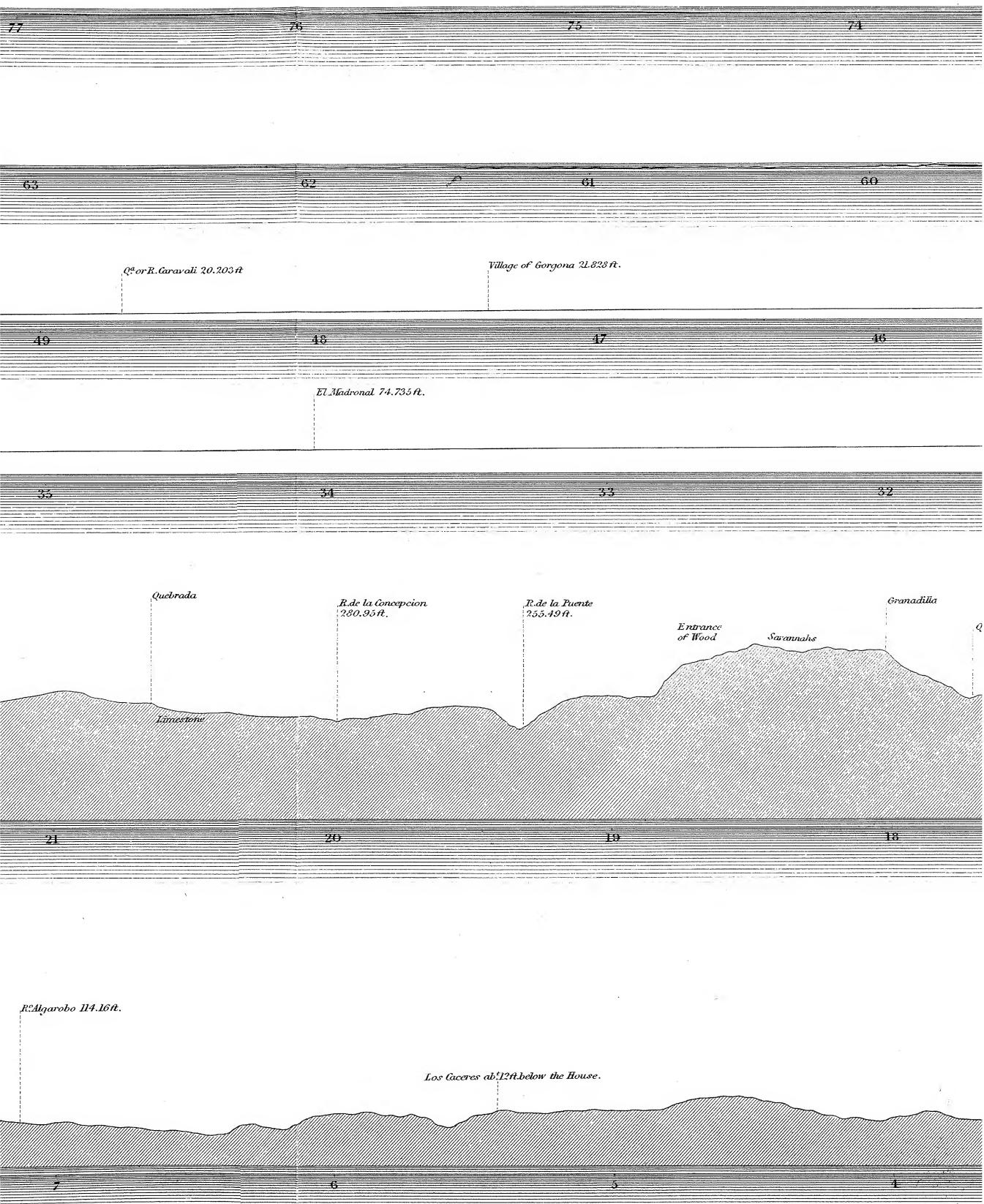
Road in Alto de las Lajas.



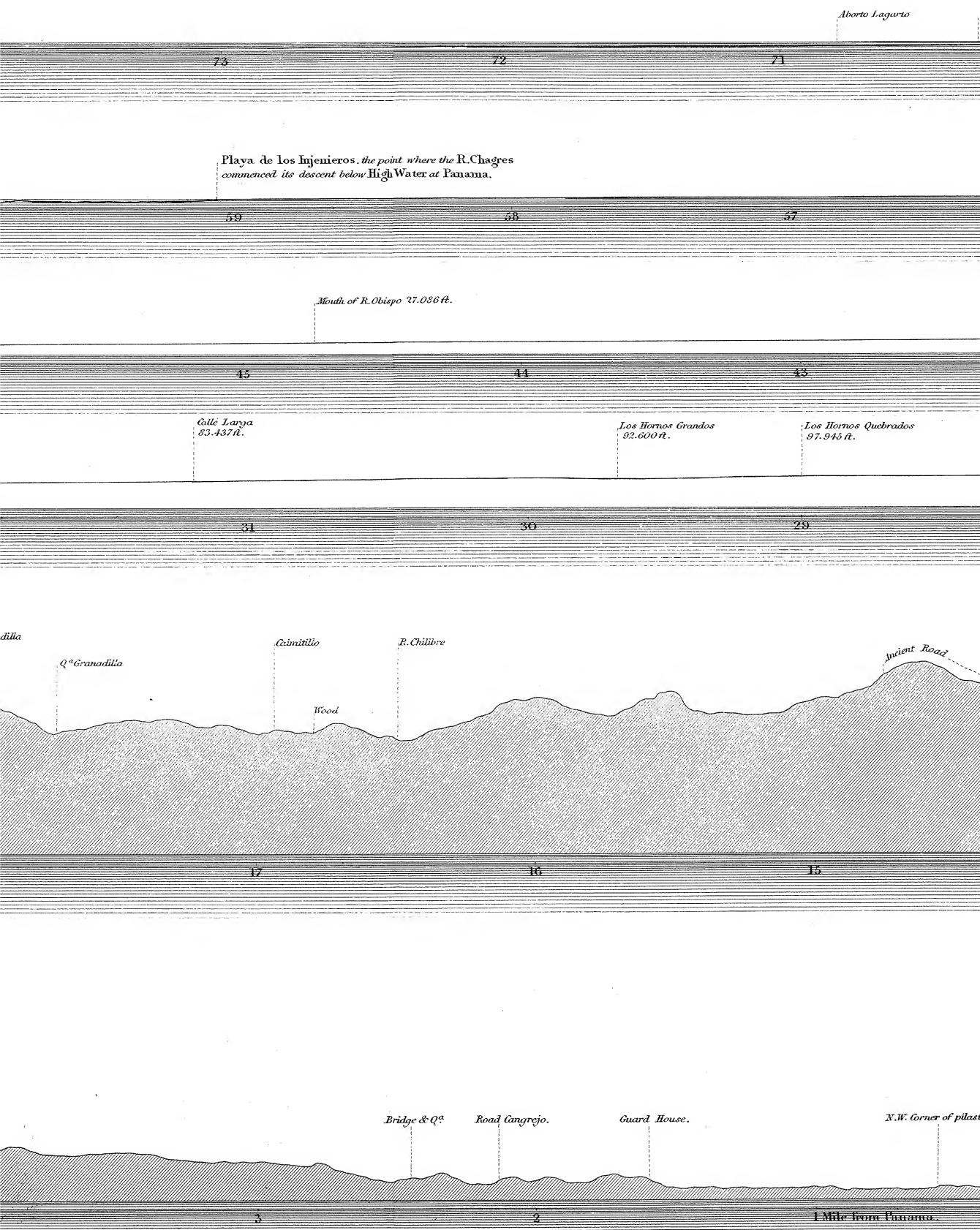
SECTION OF THE COUNTRY PASSED OVER, IN ASCERTAINING THE DIFFERENCES

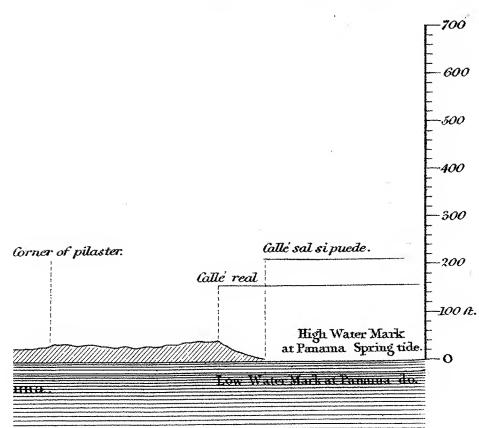
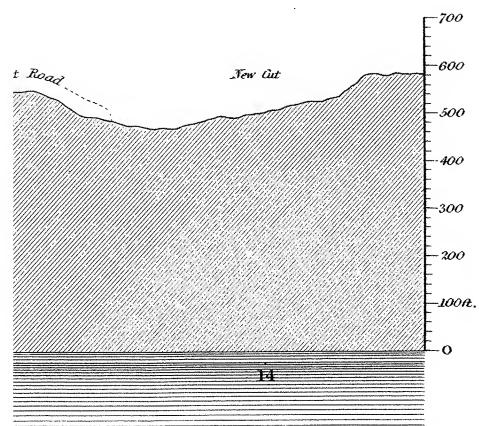
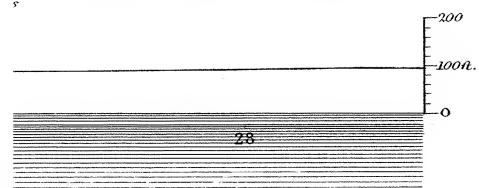
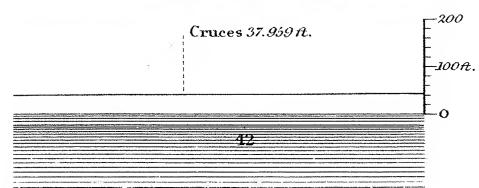
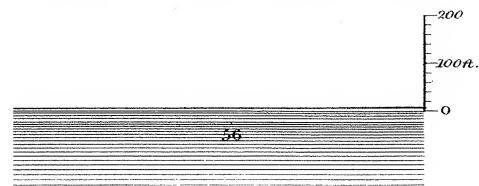
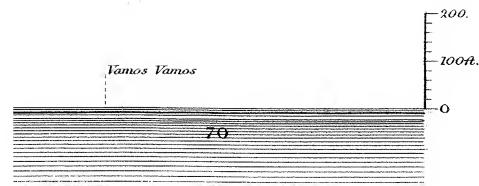


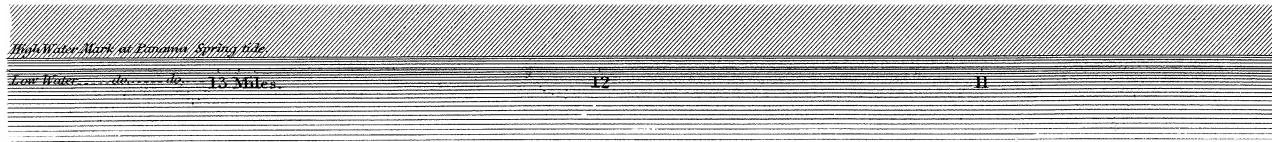
ERENCE OF LEVEL BETWEEN THE PACIFIC AND ATLANTIC OC



C O C E A N S.







High Water Mark at Panama Spring tide.

Low Water do. do. 13 Miles.

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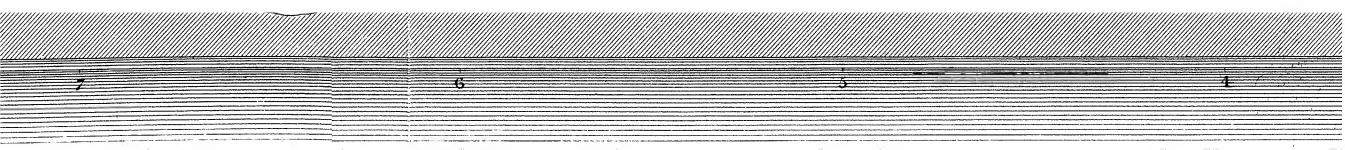
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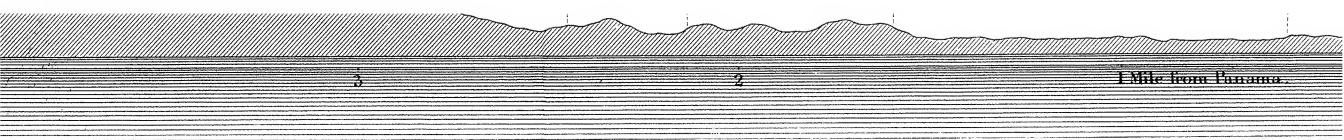
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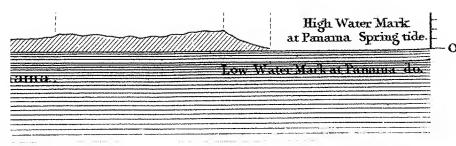
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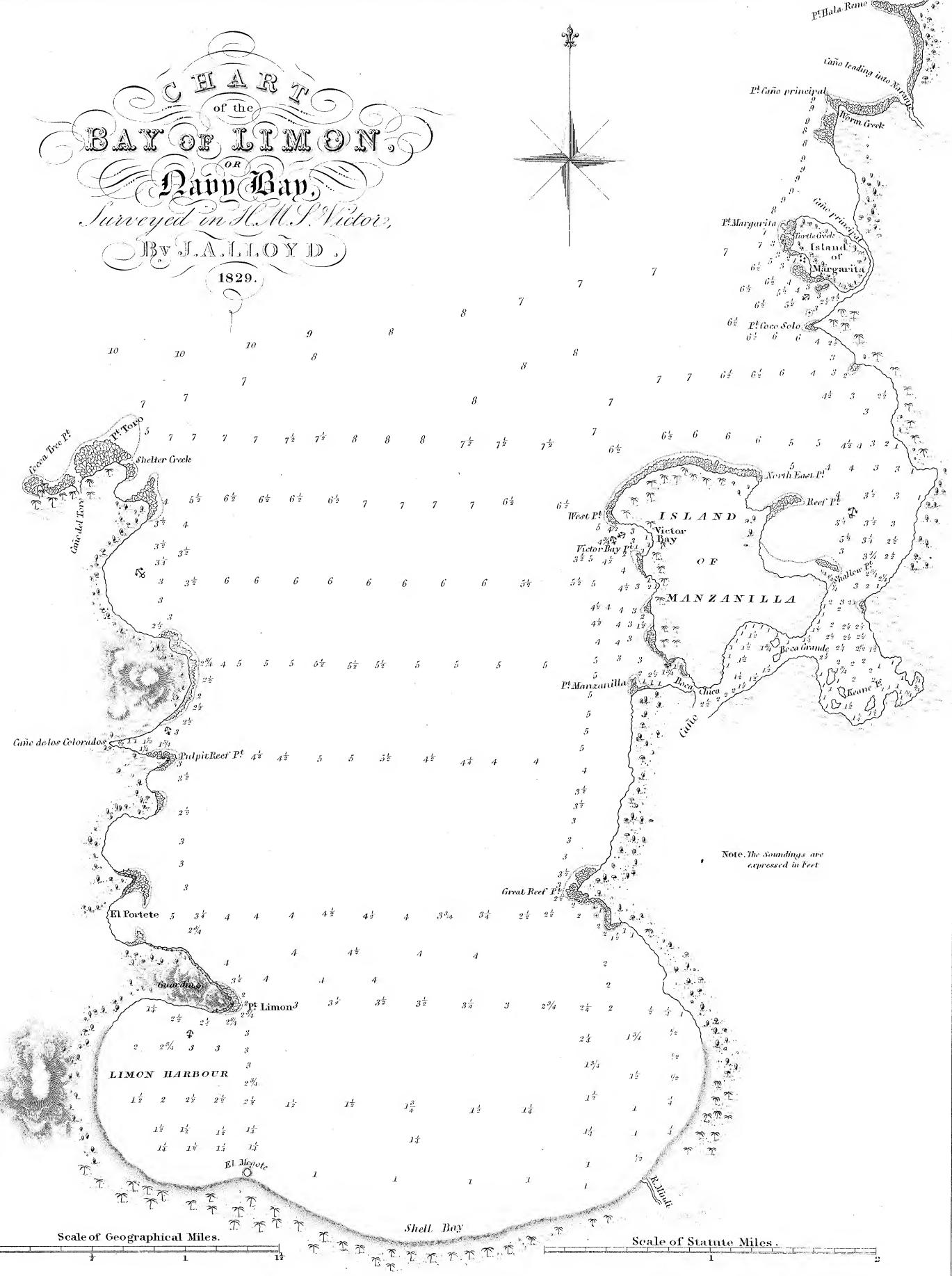
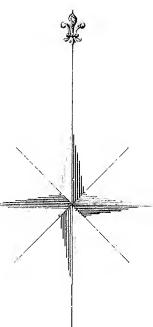


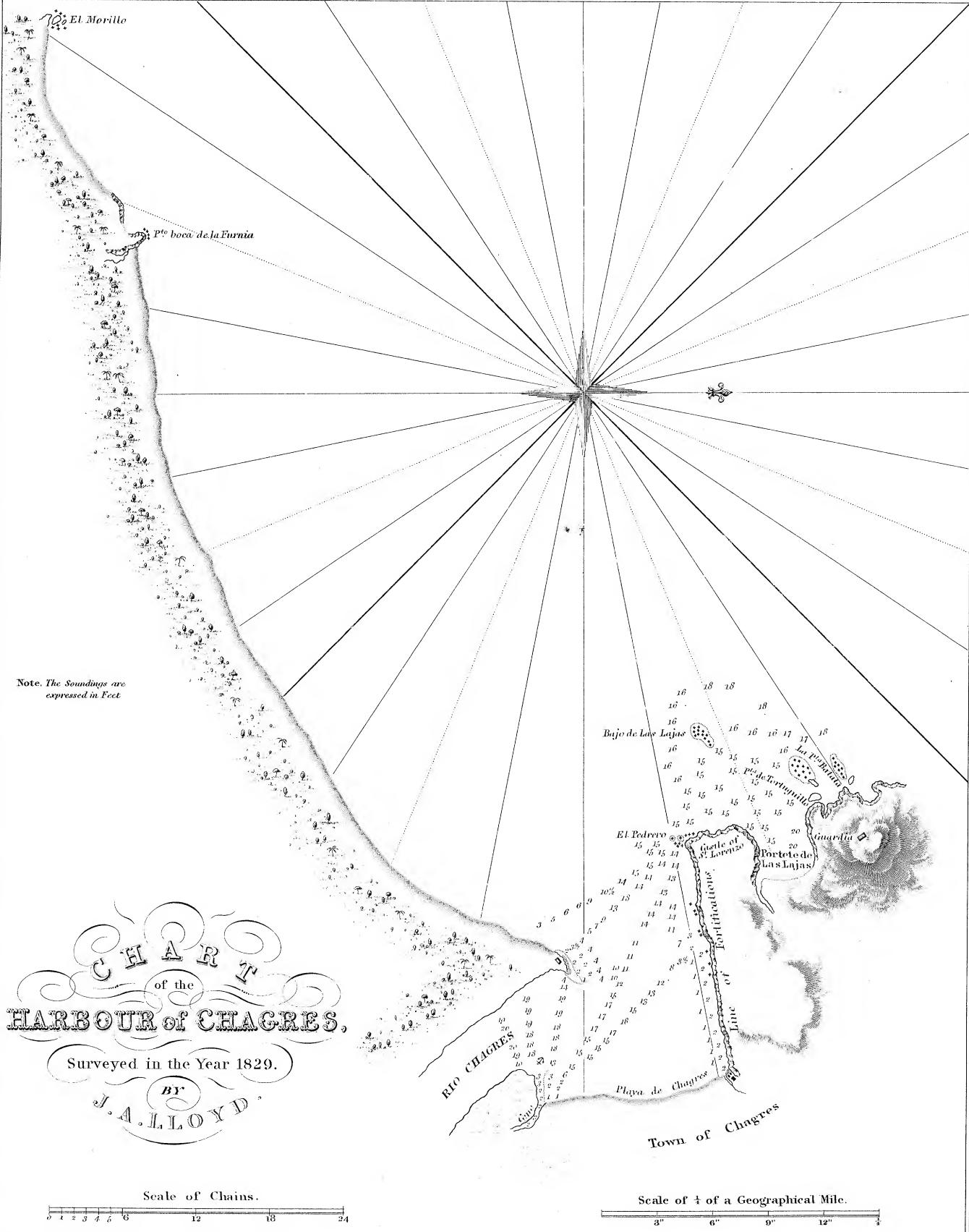




Engraved by J. Gardner.

CHART
of the
BAY OF LIMON,
OR
Davy Bay,
Surveyed in H.M.S. Victor,
By J.A. LLOYD.
1829.





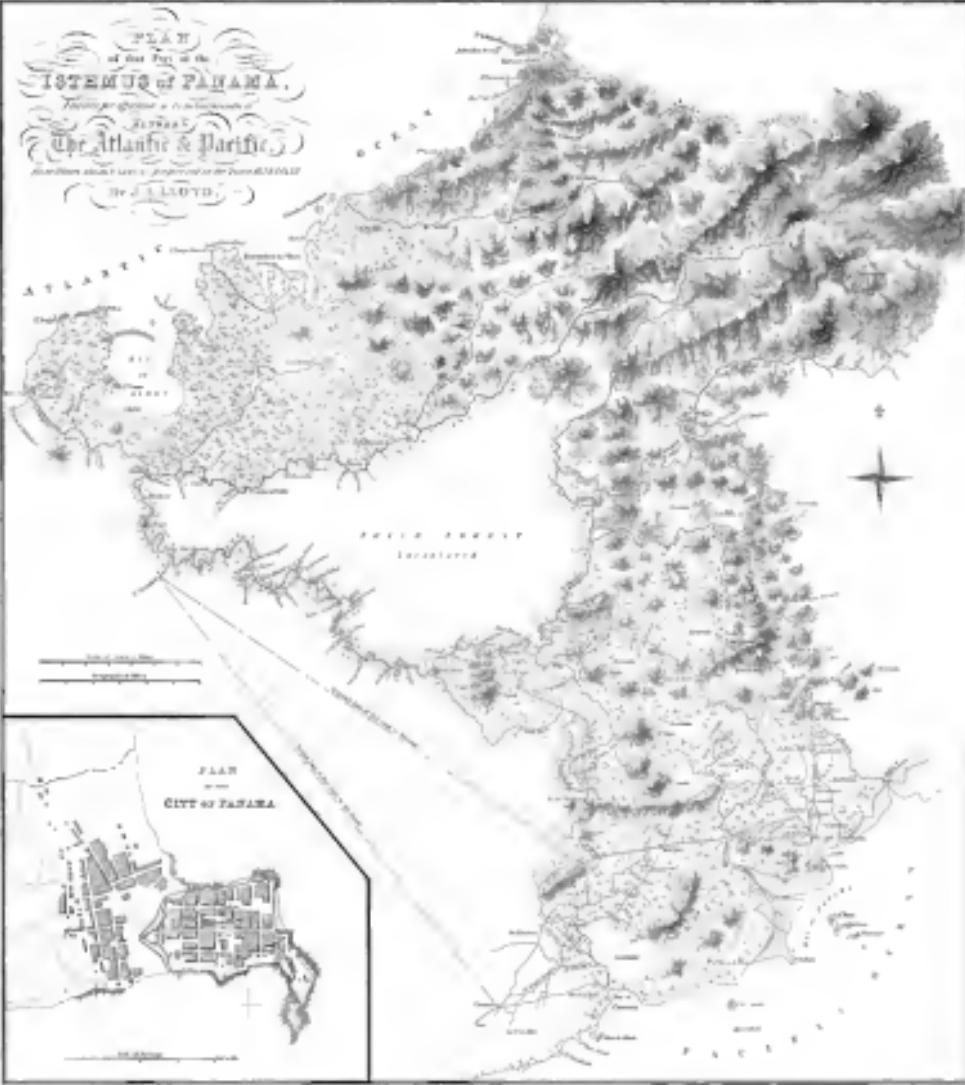


FIGURE 9. PROFILES OF THE DIFFERENCE IN MEAN AND DIFFERENCE IN LEVEL BETWEEN THE FESTUCA AND TRIFOLIUM GROUPS.

